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TAXONOMIC REVISION OF THE *POLYPODIACEOUS* GENERA OF INDIA—II: *PHYMATODES* PRESL

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ABSTRACT

The present taxonomic account has indicated that the genus *Phymatodes* is clearly distinct from *Microsorium* and cannot be merged with that genus as had been done previously by certain authors. It is represented in India by 16 species and the members of this genus usually possess fronds borne on frondiferous bases, thick coriaceous texture and sunken sori. The Indian species referable to *Crypsinus* are not at all distinct from the members of *Phymatodes*. As far as venation is concerned *Phymatodes erythrocarpa* resembles very closely species of *Polypodium* in having areolae often with one included free veinlet but it can be separated from members of that genus because of its subcoriaceous texture and altogether different sporangial paraphyses. The lateral pinnae in case of *Phymatodes stewartii* are characteristically drawn upwards. *Phymatodes crenato-pinnata* can be differentiated from the other Indian members of genus in having deltoid fronds with elongated apex, the basal pinna lobes irregularly and deeply pinnatifid and the wavy crenations of these lobes. *Phymatodes ebenipes* is very distinct in itself because of the large frondiferous leaf bases and ebeneous black polished scales. This fern is separated from other members of the group as *P. oxyloba*, *P. montana* and *P. hastata* by mainly the characters of rhizome scales. The Himalayan examples of *P. ebenipes* are separated into the typical form and var. *oakesii* (Clarke) Bir and Devi in which case the number of pinnae is much larger than the typical form and the sinuses in between the two pinna lobes are wide and rounded at base.

The trilobed fronds are met with in all the three species, namely, *P. hastata*, *P. oxyloba* and *P. montana* but these can be separated by the fact that in *P. montana* the margin of pinna lobe is repand-crenate and in *P. oxyloba* and *P. hastata* it is smooth. But in *P. hastata* as compared to *P. oxyloba* the texture is extremely thick, the main lateral veins are prominently raised on undersurface. and finally the pinnae are much broader. In *P. oxyloba* the texture is thinly subcoriaceous. In all of these species the base of the frond is decurrent on the stipe below. It may be pointed out that the South Indian material generally referable to *P. oxyloba* has been found to belong to an altogether different species, *P. montana* which possesses pinnae with crenate repand margin. *P. oxyloba* is not at all met with in South India.

As compared to the rest of the members of the genus, in *P. nigrescens*, *P. longissima*, *P. scolopendria*, *P. banerjiana* and *P. cuspidata* the rhizome scales are clathrate. Also in *P. scolopendria* and *P. banerjiana* the sori are in 2-3 irregular rows on either side of the midrib whereas in rest of the Indian species these sori are in one row.

INTRODUCTION

The genus *Phymatodes* was originally proposed by Presl in 1836 but since that time its generic status has rather been controversial. Christensen (1938) and Ching (1940) recognised it as a separate genus but Copeland (1947) merged it completely with *Microsorium* and accorded it (*Phymatodes*) the status of a section and that too, purely for the sake of convenience. Along with, Presl's genus *Crypsinus* was revived by Copeland and several Himalayan species of *Phymatodes* were transferred to it.

Holttum (1954) adopted Ching's and Christensen's views and kept *Phymatodes* distinct from *Microsorium* and also recognised *Crypsinus* as an independent genus. A few years later, while giving an account of the genus *Microsorium* in India Nayar (1961) followed Copeland and included several *Phymatodes* species under that genus.

It may be mentioned that *Crypsinus* species, according to Copeland are characterised by the presence of cartilaginous and minutely notched margin and further, according to Holttum, this genus is distinct from *Microsorium* and *Phymatodes* in its having non-clathrate scales. Mehra and Bir (1964) have pointed out that *Crypsinus* is not at all distinguishable from *Phymatodes* on the basis of characters given by Holttum and Copeland. According to them, several of the species referable to *Crypsinus* (*C. hastatus*, *C. griffithianus* and *C. ebenipes*) do not always show cartilaginous margin. Similarly the differences in scale structure in *Phymatodes* and *Crypsinus* are not sharp.

Phymatodes is quite well represented in India (Himalayas as well as South Peninsula) but so far no taxonomic account of its members is available. Further, at present a considerable confusion exists about the generic status of *Phymatodes* and *Crypsinus* and also about the member of species referable to each genus and also to *Microsorium*. Therefore, the present taxonomic account of the Indian species usually referable to *Phymatodes* was taken up.

The genus *Phymatodes* in the present context, has been taken up to include only those species which generally show a single row or rarely two rows of large sunken sori on either side of the midrib and possess generally coriaceous texture with hidden venation, but as a rule exhibit prominent main vein. These species also characteristically bear fronds on thick jointed short but erect frondiferous apices. The members can clearly be separated from those of *Microsorium* in which the sori are always present irregularly scattered in several rows on either side of the midrib and the frondiferous leaf bases are absent. The Indian species referable to genus *Crypsinus* by Copeland are also treated in *Phymatodes* because they are not separable on any dependable character.

Phymatodes Presl, Tent. Pterid. 195. Pl. 8, f. 12, 14, 15, 19, 20. 1836; Ching in Contri. Inst. Bot. nat. Acad. Peiping 2: 53. 1933; C. Chr. in F. Verdoorn's *Manual of Pteridology* p. 547, 1938.

Rhizome long creeping, often quite fleshy, bearing fronds in two rows, jointed to the apices of short erect bases, quite frequently scaly; scales generally nonclathrate and seldom clathrate; stipes smooth; fronds simple, pinnatifid or pinnatisect, rarely pinnate, uniform or more or less dimorphic, generally glabrous, thinly leathery or of coriaceous texture; lateral veins prominent, raised and generally naked, veinlets forming irregular areolae with several (rarely one) free included veinlets; sori large, round, generally sunk in distinct cavities which appear as protuberances on the upper surface, in generally one or rarely two regular rows on either side of the midrib of the frond if simple or of its lobes; sporangial paraphyses simple, hair-like, 2 to 7 celled and often the terminal cell glandular; annulus cells 9-20; spores non perisporiate, bilateral, often granulated or spiny in several species.

It is chiefly a genus of Asia-Polynesia with about 100 species of different size and habit. Unlike the Malayan species, the Indian members have both clathrate and non-clathrate, often bicolourous scales. The genus is represented in India by 16 species. Out of these, as many as 13 species are met within the Himalayas with *P. stewartii* and *P. oxyloba* being endemic to the region. *P. banerjiana* is known only under cultivation. From South India six species, namely *P. hastata, P. montana, P. nigrescens, P. longissima, P. scolopendria* and *P. cuspidata* are recorded. Except for *P. montana* and *P. scolopendria*, all the rest four are common with the Himalayas. It is interesting to point out that several of the Indian species of *Phymatodes* such as *P. griffithiana, P. malacodon, P. erythrocarpa, P. stracheyi, P. crenato-pinnata* etc. are also recorded from China particularly Yunnan region. Almost all the species are epiphytic or lithophytic and very few are terrestrial. *Phymatodes erythrocarpa, P. stracheyi* and *P. malacodon* are high altitude ferns and grow on exposed rocks generally above 3,000 m altitude.

Three species, *P. griffithiana*, *P. rhynchophylla* and *P. cuspidata* are only confined to the Eastern Himalayas whereas *P. ebenipes, P. oxyloba, P. stewartii* and *P. erythrocarpa* are distributed throughout the Himalayas from Kashmir eastward to Darjeeling, Sikkim and Assam.

KEY TO THE SPECIES

- A. Fronds simple :
  - B. Sori always confined to long acuminated narrow apex of the frond ... ... *P. rhynchophylla*
  - B. Sori extending more than half the way to the base of the frond ... ... *P. griffithiana*

- A. Fronds deeply pinnatifid :
  - B. Rhizome thin, slender, upto 3 mm in diameter :
    - C. Pinna lobe margin serrulate, and with mucronate spinescent teeth ... *P. malacodon*
    - C. Pinna margin almost smooth or serrulate but without mucronate-spinescent teeth :
      - D. Under surface of lamina densely villose ... ... *P. erythrocarpa*
      - D. Under surface of lamina glabrous :
        - E. Lateral pinnae lobes conspicuously ascending upwards, texture thinly subcoriaceous, venation partly distinct ... ... *P. stewartii*
        - E. Lateral pinnae lobe spreading and not ascending, texture subcoriaceous, venation indistinct :
          - F. Terminal pinna lobe the largest, margin of pinna lobes serrulate, sinuses generally acute and narrow ... ... *P. stracheyi*
          - F. Terminal pinna not the largest, margin of pinna lobes crenate and at least in some of these irregularly pinnatifid, sinuses in between lobes much broader ... ... *P. crenato-pinnata*
  - B. Rhizome thick, stout, always more than 4 mm in diameter:
    - C. Scales non-clathrate :
      - D. Scales ebeneous brown-black, polished and shinny, frondiferous bases on rhizome prominent ... ... *P. ebenipes*
      - D. Scale light-brown, not ebeneous and shiny :

E. Main lateral vein much raised on under surface, texture thick, rough and coriaceous with thick cartilaginous margin ... ... *P. hastata*

E. Main lateral vein not much raised on under surface, texture thin and subcoriaceous.

F. Margin of the pinna lobe smooth, frondiferous bases on rhizome prominent ... ... *P. oxyloba*

F. Margin of the pinna lobe clearly dentate or notched ... ... *P. montana*

C. Scale on rhizome clathrate :

D. Sori in one row on either side of the midrib, sporangial paraphyses long stalked and club-shaped with head consisting of 5-6 cells, arranged in two rows :

E. Main lateral veins prominent, pinna lobes usually less than 10 pairs, 3-4.7 cm wide ... ... *P. nigrescens*

E. Main lateral veins not prominent, pinna lobes 10-20 pairs, 1-2½ cm wide ... *P. longissima*

D. Sori in two or three irregular rows on either side of the midrib, sporangial paraphyses simple, elongated, 3-5 celled and hair-like:

E. Lobes usually 2-5 pairs (rarely more), sinuses 1.5 times wider than lobes, texture coriaceous, 2-3 primary areolae on each side of the midrib ... ... *P. scelopendria*

E. Lobes 5-11 pairs (rarely more), sinuses 2.5 times wider than lobes, texture herbaceous, 1-2 primary areolae of each side of midrib ... ... *P. banerjiana*

A. Fronds clearly pinnate, pinnae 6-15 pairs, clearly stalked, at least the basal ones (stalk upto 1 cm), rhizome scales clathrate, sporangial paraphyses long, 5-10 celled, hair-like ... ... *P. cuspidata*

DESCRIPTION OF THE SPECIES

Phymatodes rhynchophylla (Hook.) Ching in Contr. Inst. Bot. nat. Acad. Peiping 2: 69. 1933. Mehra & Bir in Res. Bull. Panjab Univ. (n.s.) 15: 170. 1964. *Polypodium rhynchophyllum* Hook., Ic. Plant. t. 954. 1854, and Spec. Fil. 5: 65. 1863; Clarke in Trans. Linn. Soc. Lond. II. Bot. 1: 560. 1880; C. Chr., Index. Fil. 560. 1906. *Pleopeltis rhynchophylla* (Hook.) Moore, Index Fil. 78. 1857; Bedd., Ferns Brit. India, t. 9, 1865, and Handb. Ferns Brit. India, 353, t. 198. 1883 (as *rhyncophylla*). *Phymatopsis rhynchophylla* J. Smith, Hist. Fil. 104. 1875. *Crypsinus rhynchophyllus* (Hook.) Copel., Gen. Fil. 206. 1947.

Rhizome widely creeping, branched, slender, 1 mm in diameter, densely paleaceous; scales non-clathrate, light-brown linear lanceolate or subulate with acuminate apex, margin smooth or occasionally with few projections, 3-4 mm long and ½-1 mm wide at base; stipes scattered, about ½-1½ cm apart, slender light-brown, upto 4 cm long of sterile frond and 5-10 cm of fertile frond; fronds dimorphic, subcoriaceous in texture, glossy, slightly thickened and naked on both surfaces, light green to dull-brown in colour, sterile frond 2-4 cm long, elliptical to ovate, apex obtuse, margin nearly smooth or remotely crenate, fertile lamina 8-15 cm long and 1-1½ cm wide, lanceolate, long acuminate towards apex and attenuated near the base, margin remotely crenate in the lower ⅔ portion and undulate crenate in the upper part; venation prominent on both surfaces especially the main lateral veins, the costules connected by transverse veins forming areolae with free included veinlets ending in hydathodes; sori in a single row on either side of the midrib and mostly confined to apical acuminate narrow part, when mature very large and covering the lamina surface completely, round to oblong, dark-brown; sporangial paraphyses 3-6 celled, uniseriate, club-shaped, hair-like structures; annulus cells 11-14; spores brown, bilateral, reniform or plano-convex, exine thick, 54-64×28-44 μ (Figs. 1, 14-16).

It grows epiphytically on rocks quite frequently in the Eastern Himalayas, North Sikkim and Assam between 1,200-2,400 m altitude.

Distribution : North India and Philippines.

This species is easily recognizable on the basis of dimorphic fronds. The sori are characteristically present towards the narrow acuminated apex.

*Specimens examined** : EASTERN HIMALAYAS: SIKKIM: Chungthang-Lachen Road (2,400 m), *Bir* 1042, July 1958 (PAN 3668-71); *Levinge* Oct. 1883 (CAL); *King's* Oct. 1883 (CAL); 1,800 m, Nov. 1882 (CAL); Chungthang (1,500 m), *Gammie* July,

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*Following abbreviations as proposed by Lanjouw and Stafleu (1961) in the *Index Herbariorum* are used :

CAL	Central National Herbarium, Botanical Survey of India, Sibpur, Howrah.
US	United States National Herbarium, Smithsonian Institution, Washington D.C.
K	Royal Botanic Gardens, Kew.
BM	British Museum, London.
BLAT	Blatter Herbarium, St. Xavier's College, Bombay.
MH	Botanical Survey of India, Southern Circle, Coimbatore.
PAN	Panjab University Herbarium, Chandigarh (not included in the Index Herbariorum).

1892 (CAL). Assam: Shillong (1,200 m), *Mann* Oct. 1888 (US 329702); 1,350 m, Oct. 1871 (US 816728); Duphla Hills (2,220 m), *Lister* in 1874 (CAL); Khasia (1,200 m), *J. D. Hooker* and *T. Thomson* (CAL); 1,350 m, *Clarke* (CAL 40075); 1,200 m, *Clarke* 18851, Oct. 1872 (CAL); 1,200 m, *Clarke* 5653, Oct. 1867 (CAL); Feb. 1851 (CAL); 1,200 m, *J. D. Hooker* and *T. Thomson* March. 1885 (CAL).

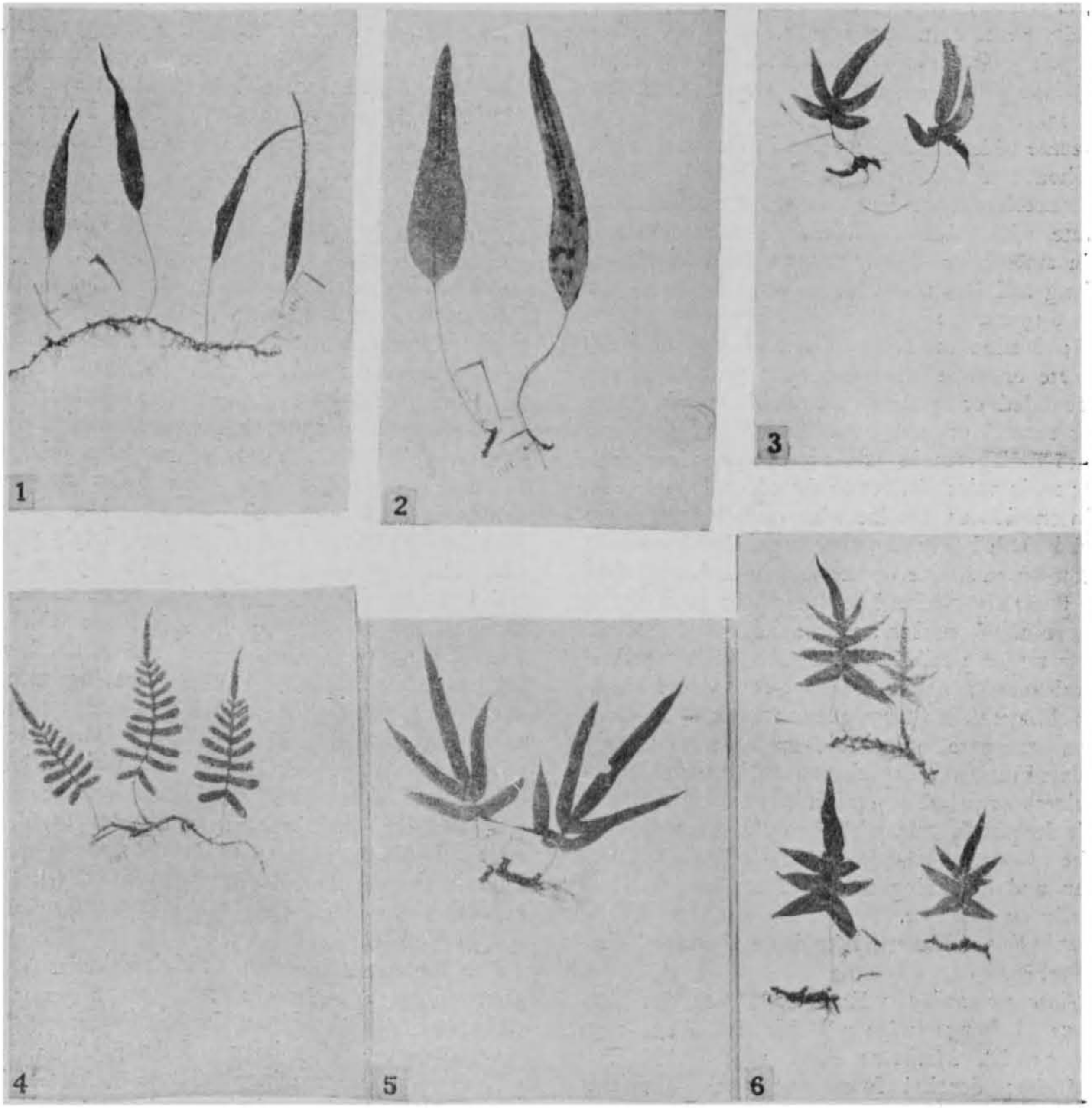


Plate I (Figs. 1-6)
1. *Phymatodes rhynchophylla* (Hook.) Ching (PAN 3669). 2. *Phymatodes griffithiana* (Hook.) Ching (PAN 3556). 3. *Phymatodes malacodon* (Hook.) Ching (PAN 3710). 4. *Phymatodes erythrocarpa* (Mett. ex Kuhn) Ching (PAN 2486). 5. *Phymatodes stewartii* (Bedd.) Ching (PAN 2601). 6. *Phymatodes stracheyi* Ching (PAN 3657).

Phymatodes griffithiana (Hook.) Ching in Contr. Inst. Bot. nat. Acad. Peiping 2: 71. 1933. Mehra & Bir in Res. Bull. Panjab Univ. (n.s.) 15: 170. 1964. *Polypodium griffithianum* Hook., Ic. Plant.

t. 951. 1854, and Spec. Fil. 5: 62. 1863; Clarke in Trans. Linn. Soc. Lond. II. Bot. 1: 560. 1880; C. Chr. Index Fil. 531. 1906. *Pleopeltis griffithiana* (Hook.) Moore, Index Fil. 78. 1857; Bedd., Handb. Ferns Brit. India 354. t. 199. 1883. *Phymatopsis griffithiana* J. Smith, Hist. Fil. 104. 1875. *Crypsinus griffithianus* (Hook.) Copel., Gen. Fil. 206. 1947.

Rhizome wide creeping 2-4 mm in diameter, scaly throughout; scales light to dark-brown, peltate linear-lanceolate with long drawn out apex, non-clathrate, with middle cells slightly dark coloured, margin smooth or slightly uneven, base broad, 4-9 mm long and ½-1½ mm wide at base; stipes ½-1 cm apart, 8-15 cm long, erect, firm glabrous, light-brown; lamina 10-15 cm long and 3-5 cm wide, lanceolate or ovate-lanceolate, apex acuminate, the base rounded or suddenly narrowed, margin more or less repand or undulated, slightly cartilaginous light to dark-green in colour; texture thick coriaceous; main veins distinct to the edges, lateral veinlets inconspicuous, areolae with copious free single forked included veinlets; sori large, dark-brown, in one row on each side of the midrib and very close to it, generally confined to the upper half of the frond, rounded, sunken; sporangial paraphyses extremely rare, 2-3 celled, filamentous with terminal cell thickened; annulus cells 9-16; spores dark-brown, bilateral, reniform, plano-convex to concavo-convex, exospore quite thickened and minutely granulated (in several specimens of abnormal shapes and sizes), 41-70×28-40 μ (Figs. 2, 17-20).

It is frequently met with between 1,200-2,700 m in the Eastern Himalayas—Darjeeling, Sikkim, Bhutan and extending eastwards to Assam. It is generally an epiphyte.

Distribution: Eastern Himalayas, Burma, China and Borneo.

Specimens examined: EASTERN HIMALAYAS: DARJEELING: Lebong (1,650 m), *Bir* 80, Aug. 1952 (PAN 959-60), *Malhotra* Aug. 1954 (PAN 957-58, 961-63); Senchal forest (2,550 m), *Malhotra* 746, July 1957 (PAN 1578, 3585-86, 3636); 2,250 m, *Clarke* Aug. 1875 (US 41890). SIKKIM: Near Lachen (2,400 m), *Bir* 1045, July 1958 (PAN 3586, 3701-02); 2,100 m, Nov. 1882 (CAL); 1,800 m, *King's* 4143, Sept. 1878 (CAL); 1,500-1,800 m, *J. D. Hooker* (CAL); Yakla (2,700 m), *Clarke* 332, Oct. 1869 (CAL). ASSAM: Khasia Hills (900-1,200 m), *Mann* July 1888 (US 329703); 1,200 m, *Mann* July 1890 (CAL); 6,900 m, *J. D. Hooker & T. Thomson* July 1894 (CAL); Manipur (1,800 m), *Watt* April 1882 (CAL); Naga Hills, *Prain* July 1886 (CAL).

Phymatodes malacodon (Hook.) Ching in Contr. Inst. Bot. nat. Acad. Peiping 2:83, 1933; Alston & Bonner in Candollea 15: 207. 1956; Mehra & Bir in Res. Bull. Panjab Univ. (n.s.) 15: 172. 1964. *Polypodium malacodon* Hook., Spec. Fil. 5: 87. 1863; Clarke in Trans. Linn. Soc. Lond. II. Bot. 1: 564. 1880; C. Chr., Index Fil. 543. 1906. *Pleopeltis malacodon* Bedd., Handb. Ferns Brit. India 363. 1883 (pro parte), non *P. malacodon* Bedd., Ferns Brit. India Suppl. 23. t. 387. 1876. *Crypsinus malacodon* (Hook.) Copel., Gen. Fil. 206. 1947.

Rhizome stout but thin, 1-3 mm in diameter, widely creeping, densely scaly, whitish in colour beneath the paleae; scales dark-drown, broadly ovate-lanceolate, acuminate, marginal projection very much elongated and prominent, central region dark-brown; stipes 1-8 cm (rarely 15 cm) long, thin, yellowish-brown, naked, with few scales at base; lamina 6-25 cm long and 3-15 cm wide, deltoid-ovate, subcordate at base, acuminate, deeply pinnatifid almost to the rachis, pinna lobes 6-9 cm long and ½-1¾ cm wide, ovate-lanceolate, acute or acuminate, 1-4 pairs, excluding the apical one which is often the largest, sinuses narrow and acute, lowest pair spreading, upper ones often ascending, margin serrulate, teeth mucronate and spinescent; texture subcoriaceous, glabrous; only main lateral veins prominent, areolae small and fine with included veinlet; sori close to and on either side of the midrib, rounded, dark-brown; paraphyses small, 2-celled, simple, hair-like; annulus cells 10-15; spores smooth, reniform to oblong, plano-convex, yellowish or dark-brown (irregularly sized in some), 35-66×19-45 μ (Figs. 3, 21-25).

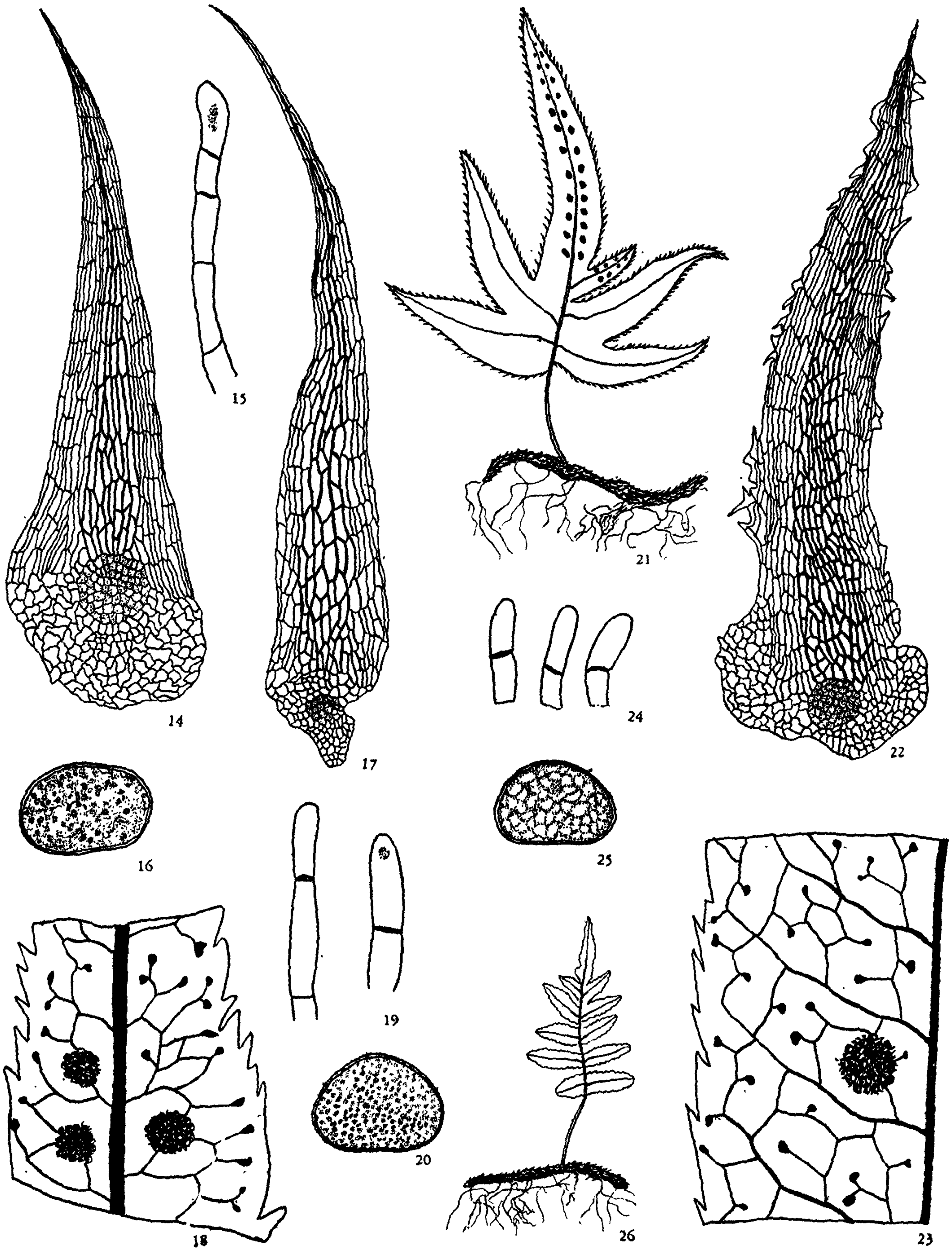
It is the commonest fern at high altitudes (2,700-3,900 m) on exposed rocks or seldom on trees especially silver firs throughout the Himalayas.

Distribution: Himalayas and South China.

In general aspect quite similar to *P. hastata* but much smaller in size and also the base of the frond is scooped out (instead of being decurrent) and the margin of the pinna lobe is acutely serrulate with prominent teeth.

There is a wide variation in the size of the frond depending upon the habitat in which the individuals grow. Plants from high altitudes and extremely exposed situations, are very much small-sized being only 6 cm long and 3 cm wide but fully fertile.

Specimens examined: WESTERN HIMALAYAS: KANGRA: Rotang-la (3,600 m), *Walter Koelz* 5035, June-July 1933 (US 1860374). KULU: Chandrakain (3,300 m), *Walter Koelz* 158, June 1930 (US 1575207).



Explanation to figures on page 217

SIMLA: Huttoo Peak (3,000-3,150 m), *Bir* 1524, Aug. 1900 (PAN 3969-70, 4230-33); Huttoo (3,090 m), *Blanford* Sept. 1884 (US 418914); 3,00 m, *Blanford* July 1885 (US 418918). MUSSOORIE: (3,150 m), Oct.

1902 (US 595327); Nag Tiba (2,700 m), *Mackinnon* in 1879 (US 418915); 2,570 m, *Fleming* 6, Sept. 1942 (US 2017590); 2,940 m, *Fleming* 76, Sept. 1948 (US 2135446). KUMAUN: 3,600 m, *Duthie* 3693, Oct. 1884 (US 816709, 595327). EASTERN HIMALAYAS: NEPAL: Chutta s.e. of Jumla (3,150 m), *Polunin, Sykes & Williams* 5418, Sept. 1952 (US 2360463); Near Tarakot (3,300 m), *Polunin, Sykes & Williams* 2407, July 1952 (US 2360416).

Phymatodes erythrocarpa (Mett. ex Kuhn) Ching in Contr. Inst Bot. nat. Acad. Peiping 2:80, 1933; Alston & Bonner in Candollea 15: 205. 1956. Mehra & Bir in Res. Bull. Panjab Univ. (n.s.) 15: 171. 1964. *Polypodium erythrocarpum* Mett. ex Kuhn in Linnaea 36: 135. 1869; Clarke in Trans. Linn. Soc. Lond. II. Bot. 1: 565. 1880; C. Chr., Index Fil. 525. 1906. *Goniophlebium erythrocarpum* Bedd., Ferns Brit. India, Suppl., 21, t. 382. 1876, and Handb. Ferns Brit. India 319. t. 171. 1883.

Rhizome very thin, firm, wide creeping, 1-1½ mm in thickness, densely scaly; scales deciduous, small, lanceolate, non-clathrate, dark-brown, upto 2½ mm long, 1½ mm wide, linear-lanceolate, not hair pointed, margin hyaline and highly irregular due to the presence of one or 2-celled projections; stipes 3-6 cm long, slender, naked, stramineous; lamina oblong-deltoid, acuminate, 10-20 cm long and 3-6 cm wide, deeply pinnatifid near to the rachis with lower lobes quite free and terminal pinna the largest and acuminated; pinna lobes 5-10 pairs, middle ones the largest, lowest pair deflexed downwards, rest adnate, basal ones quite free from each other, wing in between very narrow (1-2 mm wide), sinuses about the width of the pinna lobes and rounded at base, 1½-3 cm long, about ½ cm wide, somewhat narrowed at base, apex rounded and obtuse or minutely acute, margin obscurely slightly repand or serrate, densely pubescent underneath, upper surface glabrous; texture rigidly subcoriaceous, colour light to yellow-green; rachis villose beneath; midrib and main lateral veins raised beneath, distinct nearly to the edge, rest of the venation obscure, areolae in one or two series, the larger areolae near the midrib and with single free included veinlet, the small areolae when present generally without a free veinlet, in large-sized lamina the free included veinlet sometimes forked; sori small, close to and in a single row on either side of the midrib, rounded, dark-brown, sunken; paraphyses long hair-like and 3-5 celled; spores yellowish-brown, reniform or plano-convex, nonperisporiate, exospore thick, reticulately granulated, 25-57 × 20-32 μ (Figs. 4, 26-29).

It is quite frequently found at high altitudes, between 2,700-3,600 m in the Himalayas; Simla, Darjeeling and Sikkim State. Also reported from Nepal. It grows epiphytically or lithophytically.

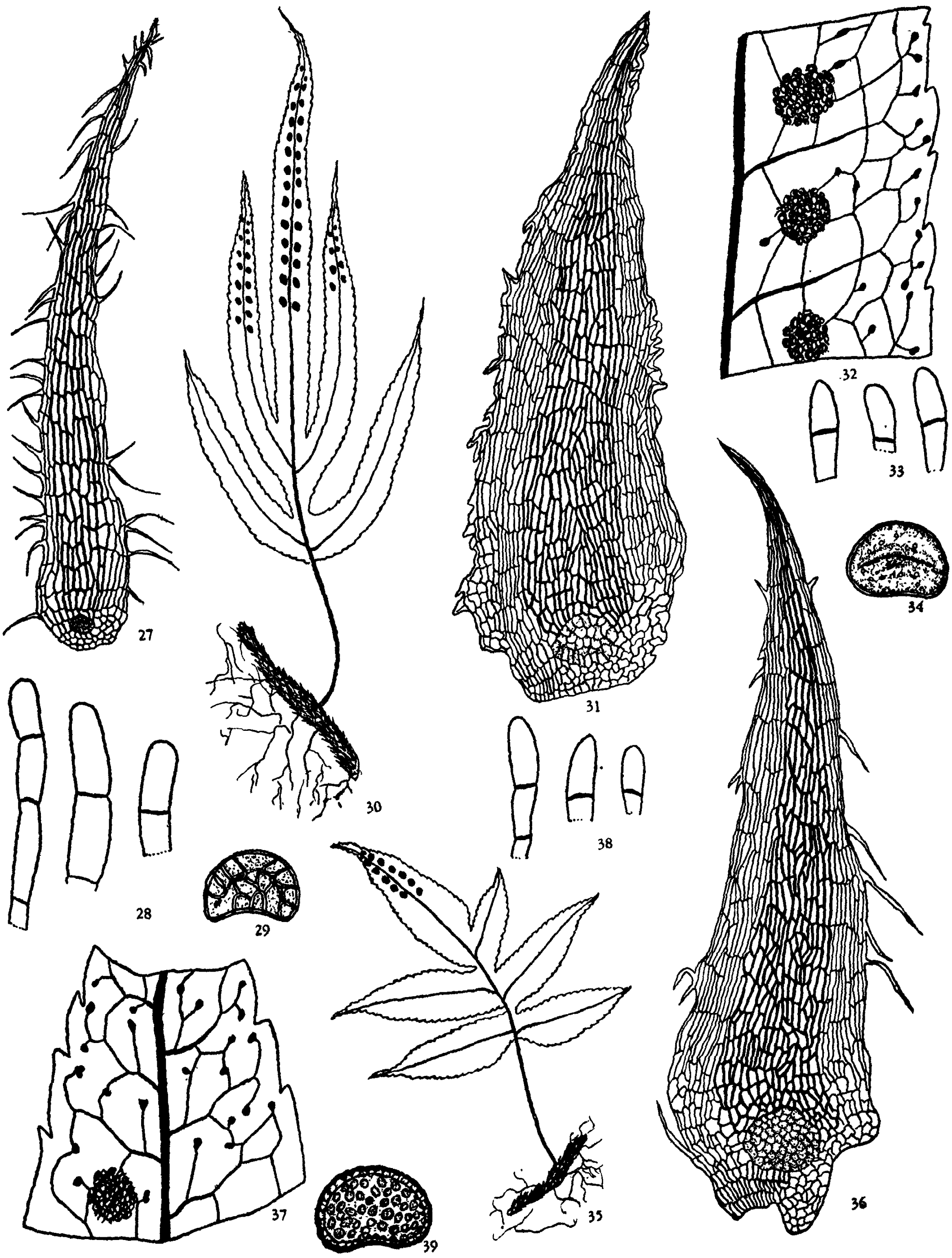
Distribution: Himalayas and China.

This small-sized fern is easily recognisable by the fact that the lower side of the lamina is densely hairy, the apices of pinna lobes are generally obtuse or minutely acute, and the areolae nearer the midrib are often with one included veinlet (like *Polypodium*) whereas the smaller ones near the margin are without any veinlet. On the basis of similar venation this fern can be referred to *Polypodium* but the subcoriaceous texture, veins raised on undersurface and altogether different sporangial paraphyses would stress its place in *Phymatodes.*

Specimens examined: WESTERN HIMALAYAS: SIMLA: Huttoo peak (3,000 m), *Bir* Aug. 1960 (PAN 4759). EASTERN HIMALAYAS: DARJEELING: Sandakphu (3,600 m), *Malhotra* Aug. 1953 (PAN 1385); Rambic (2,700 m), *Malhotra* 800, Aug. 1957 (PAN 1598); Sandakphu (3,450 m), *Leving* Oct. 1880 (US 816688). SIKKIM: Simdong (3,600 m), *Bir* 1063, July 1958 (PAN 2483-86).

Phymatodes stewartii (Bedd.) Ching in Contr. Inst. Bot. nat. Acad. Peiping 2:81. 1933; Alston & Bonner in Candollea 15: 206. 1956; Mehra & Bir in Res. Bull. Panjab Univ. (n.s.) 15:171.1964. *Pleopeltis stewartii* Bedd., Ferns Brit. India, t. 204. 1866. *Polypodium stewartii* (Bedd.) Hook & Bak., Syn. Fil. ed. ii. 554. 1874 (non Clarke, 1880). *Pleopeltis malacodon* var. *majus* Bedd., Handb. Ferns Brit. India, 363. 1883. *Crypsinus stewartii* (Bedd.) Copel., Gen. Fil. 206. 1947. *Polypodium cyrtolobum* Clarke in Trans. Linn. Soc. Lond. II. Bot. 1:563. t. 83. 1880.

Rhizome stout, thick, wide creeping, more than 3 mm in thickness, densely scaly but often glaucous because of the fallen scales; scales broadly lanceolate, bicolourous, non-clathrate, dark-brown, margin dentate due to the presence of numerous marginal projections (not so prominent in old scales), middle cells dark-brown, marginal cells hyaline, apex long acuminate and black; stipes 3-15 cm long, erect, brown in colour, glabrous or with few scales; lamina 12-35 cm long and 6-12 cm wide, lanceolate-ovate, acuminate with cordate (scooped out) or decurrent base, deeply pinnatifid to within 1-3 mm of rachis which is often scaly underneath near the base; pinnae sessile with decurrent base, 1-3 pairs excluding the terminal one which is the largest (about 1½ times the size of the lateral ones), narrow, linear-lanceolate and acuminate, upto 15 cm long, 1½ cm wide, all pointing upwards, margin slightly serrate,



Explanation to figures on page 217

teeth not mucronate; texture thinly subcoriaceous; venation quite conspicuous, main lateral veins prominent, areolae with copious free veinlets; sori in single row on either side of the midrib and a little close to it, one sorus in between two lateral veins, dark-brown, rounded, large, subimmersed; reniform or plano-convex, minutely granulated, 48-72 × 25-48 μ (Figs. 5, 30-34).

This is one of the most common species of the genus met with either epiphytically or lithophytically throughout the Himalayas between 1,500-3,600 m altitude.

Distribution : North India.

This fern can hardly be confused with any other species of the genus because all the lateral pinnae are characteristically drawn upwards (ascending at an angle of about 45°) with the result, the frond is much narrower. Also the texture is thinly subcoriaceous, making it possible to see clearly all the veinlets against light. However, there is a great variation as to the size of lamina and the number of pinnae.

Specimens examined: Western Himalayas: Simla: Narkanda (2,400 m), *Bir* Aug. 1960 (PAN 4919); Huttoo Peak (3,000 m), *Bir* 1486, Aug. 1960 (PAN 3293, 3299). Mussoorie: Tehri Road (2,100 m), *Bir* 1341, Aug. 1959 (PAN 2601-04); Park (1,800 m), *Malhotra* Aug. 1952 (PAN 1051-52); *Fleming* 23478, Aug. 1944 (US 2017592); 1,920 m, *Fleming* 637, Sept. 1948 (US 1918751); 1,800 m, *Mackinnon* in 1880 (US 816684). Eastern Himalayas: Darjeeling: Sandakphu Road (2,400 m), *Bir* 129, Aug. 1956 (PAN 1045-49); *Malhotra* Aug. 1954 (PAN 1050, 1053-54, 3050); Mani-Bhanjan-Tonglu Road (2,400 m), *Malhotra* 774, July-Aug. 1957 (PAN 1590, 3658-60, 4200); Tonglu (3,000 m), *Levinge* Aug. 1880 (US 816683). Sikkim: Simdong Lachen valley (3,300 m), *Bir* 1061, July 1958 (PAN 3705-08).

Phymatodes stracheyi Ching in Contr. Inst. Bot. nat. Acad. Peiping 2: 83. 1933; Mehra & Bir in Res. Bull. Punjab Univ. (n.s.) 15: 172. 1964. *Polypodium stewartii* Clarke in Trans. Linn. Soc. Lond. II. Bot. 1: 563. 1880 (non Bedd., 1866). *Polypodium stracheyi* Ching in C. Chr., Index Fil. Suppl. III. 159. 1934.

Rhizome rather slender, creeping extensively, 1-2 or rarely 3 mm in diameter, densely scaly; scales lax, soft, nonclathrate, bicolourous, yellow-brown, linear-lanceolate, apex acuminate, marginal projections prominent and elongated, middle cells thick walled, marginal thin walled, 2-6 mm long, ½-1½ mm wide; stipes 2-10 cm long, light-yellowish brown, glabrous, naked; lamina about as long as broad, 7-25 cm long, 6-15 cm wide, broadly deltoid-ovate, apex acuminate, deeply pinnatifid within 1-3 mm to the rachis; pinnae 2-5 pairs excluding the terminal one which is the largest, broad, straight spreading, lowest pair deflexed and somewhat broad at base, 3-8 cm long, 1-1½ cm wide, oblong-lanceolate, acuminate, sinuses very narrow, pinnae bases rather overlapping, rarely wide with round base, margin serrulate but teeth not mucronate or spinescent, colour light to dull-green, texture subcoriaceous, both surfaces glabrous; main lateral vein prominent, falling little short of midrib, secondary veinlets inconspicuous and fuse to form 2-3 series of areolae with free included veinlets; sori in one row on either side of the midrib and close to it, subimmersed; sporangial paraphyses small 2-3 celled, uniseriate; spores dark-brown, bilateral, exospore thick, coarsely ornamented, 45-61 × 26-38 μ (Figs. 6, 35-39).

It is quite frequently met with on trees or rocks at 2,100 m or above extending upto 4,200 m throughout the Himalayas (Simla, Mussoorie, Darjeeling and Sikkim).

Distribution : North India and China.

The closest relative of this species is *Phymatodes malacodon* but the two differ in the fact that the present species lacks spinescent-mucronate teeth on the pinna margin which are so characteristic of the other fern. Clarke (1880) relates this fern to *P. ebenipes* but in the opinion of the writers the two ferns are far different from each other.

Specimens examined: Western Himalayas: Mussoorie: Jaberkhet (2,100 m), *Stewart* 21053, Aug. 1944 (US 2017525); *Stewart* 14878, Aug. 1935. (US 1759657); *Stewart* 14198, Aug. 1934 (US 1759635); 1,980 m, *Fleming* 22, Aug. 1942 (US 2135393). Eastern Himalayas: Darjeeling: On way to Tonglu (2,700 m), *Bir & Malhotra* 799, July 1957 (PAN 1427, 1676, 3656-57); *Malhotra* Aug. 1954 (PAN 1014, 3051); Sandakphu (3,600 m), *Malhotra* Aug. 1953 (PAN 1042). Sikkim: Chungthang-Lachen Road (2,400 m), *Bir* 1030, July 1958 (PAN 3712-15); Lachen Valley (3,000 m), *Bir* 1075, July 1958 (PAN 2491-94).

Phymatodes crenato-pinnata (Clarke) Ching in Contr. Inst. Bot. nat. Acad. Peiping 2: 80. 1933; Alston & Bonner in Candollea 15: 206. 1956. *Poly-*

podium crenato-pinnatum Clarke in Journ. Linn. Soc. Lond. 25:99. t. 42. 1888: C. Chr., Index Fil. 519. 1906. *Pleopeltis crenato-pinnata* (Clarke) Beddome, Handb. Ferns Brit. India, Suppl. 96. 1892.

Rhizome slender, creeping, densely clothed with small lanceolate fuscous deciduous scales; stipes 8-15 cm long, slender, nearly naked; fronds elongate, triangular, 8-13 cm long, pinnatifid nearly to the rachis, glabrous; segments with shallow wavy crenation or some of the lower ones irregularly pinnatifid; main veins more or less distinct nearly to the edge, areolae with free veinlets inconspicuous except when held upto the light; sori solitary between the main veins (Fig. 40).

This species was collected from North Manipur (Eastern Himalayas) between 1,050-1,200 m altitude (Clarke, Watt). Also recorded from Nepal (Right bank of Bhote Kosi, 3,000 m) by Alston & Bonner (1956).

No specimen was available for study, therefore, the above description is taken from Beddome (1892).

Distribution: North India and China (Yunnan). This is the most distinct fern amongst the small-sized species of *Phymatodes* with slender creeping rhizome. It is easily separated by (*i*) deltoid fronds with elongated apex, (*ii*) pinna lobes with shallow wavy crenations or some of the basal ones irregularly and deeply pinnatifid, and (*iii*) the bases of the pinna lobes long decurrent on the stipe with the result the sinuses in between the lobes are much wider than their width.

Phymatodes ebenipes (Hook.) Ching in Contr. Inst. Bot. nat. Acad. Peiping 2:86. 1933; Alston & Bonner in Candollea 15: 207. 1956; Mehra & Bir in Res. Bull. Panjab Univ. (n.s.) 15: 170. 1964. *Polypodium ebenipes* Hook., Spec. Fil. 5: 88. 1863; Clarke in Trans. Linn. Soc. Lond. II. Bot. 1:564. 1880; C. Chr., Index Fil. 524. 1906. *Pleopeltis ebenipes* Bedd., Ferns Brit. India, t. 138. 1866 and Handb. Ferns Brit. India 363. 1883. *Crypsinus ebenipes* (Hook.) Copel., Gen. Fil. 206. 1947.

var. **ebenipes**

Rhizome stout, hard, creeping, thick, 5-8 mm in diameter, bears prominent frondiferous bases, densely scaly throughout; scales imbricate, adpressed, broadly ovate-lanceolate, dark-brown or nearly black polished, ebeneous, nonclathrate, margin with elongated projections, about 6 mm long and 2 mm wide; stipes quite closely placed, about ½-1 cm apart, articulated to a thick rounded base, 10-22 cm long, glabrous above, scaly at base, yellowish-brown; lamina 15-50 cm long and 10-30 cm wide, deltoid ovate; acuminate, cut down to a broadly or narrowly winged rachis which is sparsely scaly beneath; pinnae lobes numerous (upto 12 pairs), oblong-lanceolate with acute or acuminate apex, and broad decurrent base, wing on the rachis 1-4 mm wide, sinuses narrow, middle ones spreading, basal pair deflexed downward with base scooped out, 4-10 cm long, 1½-2 cm wide in the middle, terminal one of the same size, margin serrulate, teeth not mucronate; texture coriaceous, under surface somewhat whitish when dry, venation distinct, main lateral veins prominent to the margin, raised, areolae fine, small with copious free included veinlets; sori near the midrib in single row on either side of it, one in between two main veins, rounded, medium-sized; paraphyses simple 2-celled and hair like; annulus cells 9-15; spores brown, smooth, plano-convex to concavo-convex, $32\text{-}76 \times 22\text{-}48\,\mu$ (Figs. 7, 41-43).

It is commonly met with throughout the Himalayas from Dalhousie eastwards to Assam between 1,500-3,600 m altitude. The plants are found with equal frequency on trees as well as on rocks.

Distribution: Himalayas, China (Yunnan) and Borneo.

The chief characteristics of this fern are the thick frondiferous leaf bases and ebeneous nearly black polished scales. These scales on the older rhizomes become rusty yellowish-brown but it can be sorted out from *P. oxyloba* by the serrulate margin and coriaceous texture. It can conveniently be confused with *P. hastata* in the absence of raised veins because both have similar texture and rhizome but *P. hastata* has always broader and fewer pinna lobes. There is a great variation as to the size of the lamina.

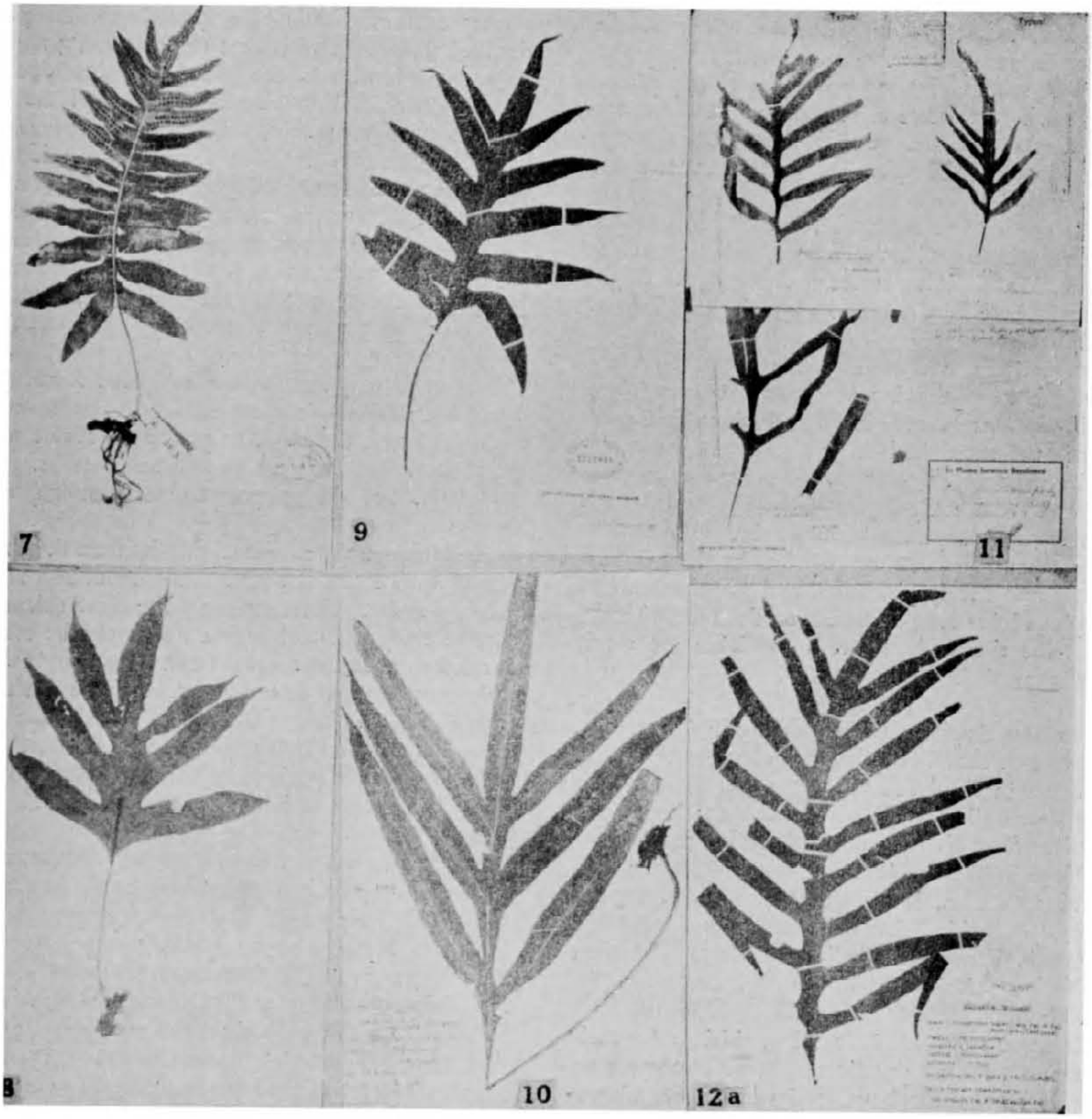
Specimens examined: WESTERN HIMALAYAS: SIMLA: Near Shali (3,000 m), *Bir* 1528, Aug.-Sept. 1960 (PAN 4223-4227); Shali Peak (3,000-3,150 m); *Bir* 1531, Sept.-Oct. 1960 (PAN 4228-29, 4943-44); Huttoo (3,090 m), *Blanford* Sept. 1884 (US 418901-02). MUSSOORIE: Nag Tiba (1,200 m), *Mackinnon* 1885, in 1879 (US 418899); 2,700 m, *Stewart* 21368, Aug. 1944 (US 2017561); *Fleming* 83, Sept. 1942 (US 2135455); Garhwal (1,800-2,100 m), *Duthie* 5174, Oct. 1885 (US 816687). EASTERN HIMALAYAS: DARJEELING: Sandakphu (3,600 m), *Malhotra & Bir* 793, July-Aug. 1957 (PAN 1589, 1592, 3651-53, 4198-99); Tonglu-Sandankphu Road (2,400 m), *Bir* 128, Aug.-Sept. 1956 (PAN 1097-99, 4118-19); *Malhotra* Aug.

1953-54 (PAN 624, 1096, 1100-03, 3046-47); NEPAL. Jumla (2,850 m), *Polunin, Sykes* & *Williams* 5451, Sept. 1952 (US 2360467).

According to Beddome (1892) Clarke's *Polypodium ebenipes* var. *parishii* is *Drynaria.*

var. **oakesii** (Clarke) comb. nov. *Polypodium ebenipes* Hook. var. *oakesii* Clarke in Trans. Linn. Soc. Lond. II. Bot. 1: 564. 1880.

Lamina large-sized cut down nearly to the main rachis (within 2 mm), pinna lobes upto 15 pairs,



7. *Phymatodes ebenipes* (Hook.) Ching (PAN 3716). 8. *Phymatodes hastata* (Thbg.) Ching (PAN 3720). 9. Isotype specimen of *Phymatodes oxyloba* (Wall. ex Kunze) Presl (=*Polypodium oxylobum* Wallich, US 1277841), 10. *Phymatodes nigrescens* (Bl.) J. Smith (MH 38420). 11. Type of *Phymatodes scolopendria* (Burm. f.) Ching (=*Polypodium alternifolium* Willd.). 12a. Isotype of *Phymatodes banerjiana* Pal & Pal (US 2358072).

narrow, caudate, upto 15 cm long, 1½ cm wide, acuminate, spreading; lowest pair widely deflexed, sinuses in between lobes wide (at least of the width of the lobe or usually wider) and rounded (Fig. 44).

It is recorded from Darjeeling (2,100 m) area only in the Eastern Himalayas.

As far as the shape of the pinnae and sinuses in between them are concerned var. *oakesii* is quite unlike the common form of var. *ebenipes* and is very distinct. But for the similar rhizome scales and other common characteristics with var. *ebenipes* it could easily be of specific rank.

Specimens examined: EASTERN HIMALAYAS: DARJEELING: *Malhotra* Aug. 1954 (PAN 964-67).

Phymatodes hastata (Thunb.) Ching in Sinensia, 3: 344. 1933. Mehra & Bir in Res. Bull. Panjab Univ. (n.s.) 15: 170. 1964. *Polypodium hastatum* Thunb., Fl. Jap. 335. 1784; Hook. & Bak., Syn. Fil. ed. ii. 361. 1874; Clarke in Trans. Linn. Soc. Lond. II. Bot. 1: 562. 1880; C. Chr., Index Fil. 532. 1906. *Pleopeltis hastatus,* Moore, Index Fil. 346. 1862; Bedd., Handb. Ferns Brit. India. 362. 1883 (pro parte). *P. malacodon* Bedd., Ferns Brit. India. Suppl., 23, t. 387. 1876. *Crypsinus hastatus* (Thunb.) Copel., Gen. Fil. 206. 1947.

Rhizome creeping, stout, thick, 4-8 mm in diameter, densely scaly; scales pale or dull-brown, spreading, lanceolate-linear with long acuminated apex, 3-6 mm long and 1-2 mm broad at the base, margin with few projections; stipes stramineous to dull-brown, naked, 5-15 cm long, scales present only on the thickened base; lamina almost as broad as long, 12-25 cm long and 14-22 cm wide, trilobed or deeply pinnatifid to within 1-2 cm of the rachis, lateral lobes like the terminal one; pinnae lobe 1-3 pairs, 8-15 cm long, 2-4 cm wide, oblong-lanceolate, cartilaginous, margin entire but repand on drying, narrowed on base and acuminated on apex, lowest pair conspicuously spreading outward and decurrent on the stipe, sinuses in between lobes narrow (less than half the width of the lobe); rachis almost naked and glossy; texture coriaceous, firm and rough, both sides glabrous; venation conspicuous, midrib and main lateral veins very much raised and prominent beneath, distinct to the edge, parallel with conspicuous 3-4 series of areolae between them, areolae with free included veinlets with clavate apices; sori on either side of the midrib in single row, more near the midrib than the margin, one in between two lateral veins, conspicuous, sunken, large, rounded, brown; sporangial paraphyses hair-like uniseriate, long, 3-6 celled with apical cell swollen; annulus cells 14-17; spores dark-brown, reniform, plano-convex to concavo-convex, tuberculate-spinescent, 41-80 × 24-50 μ (Figs. 8, 45-49).

It is frequently met with in the Himalayas from Simla eastward to Sikkim and Assam between 1,500-2,700 m altitude. The plants usually grow on moist rocks or epiphytically. Reported from South India on Palni Hills (Kodaikanal) at almost 2,100 m.

Distribution: Himalayas, South India, Japan, China, Formosa and Philippines.

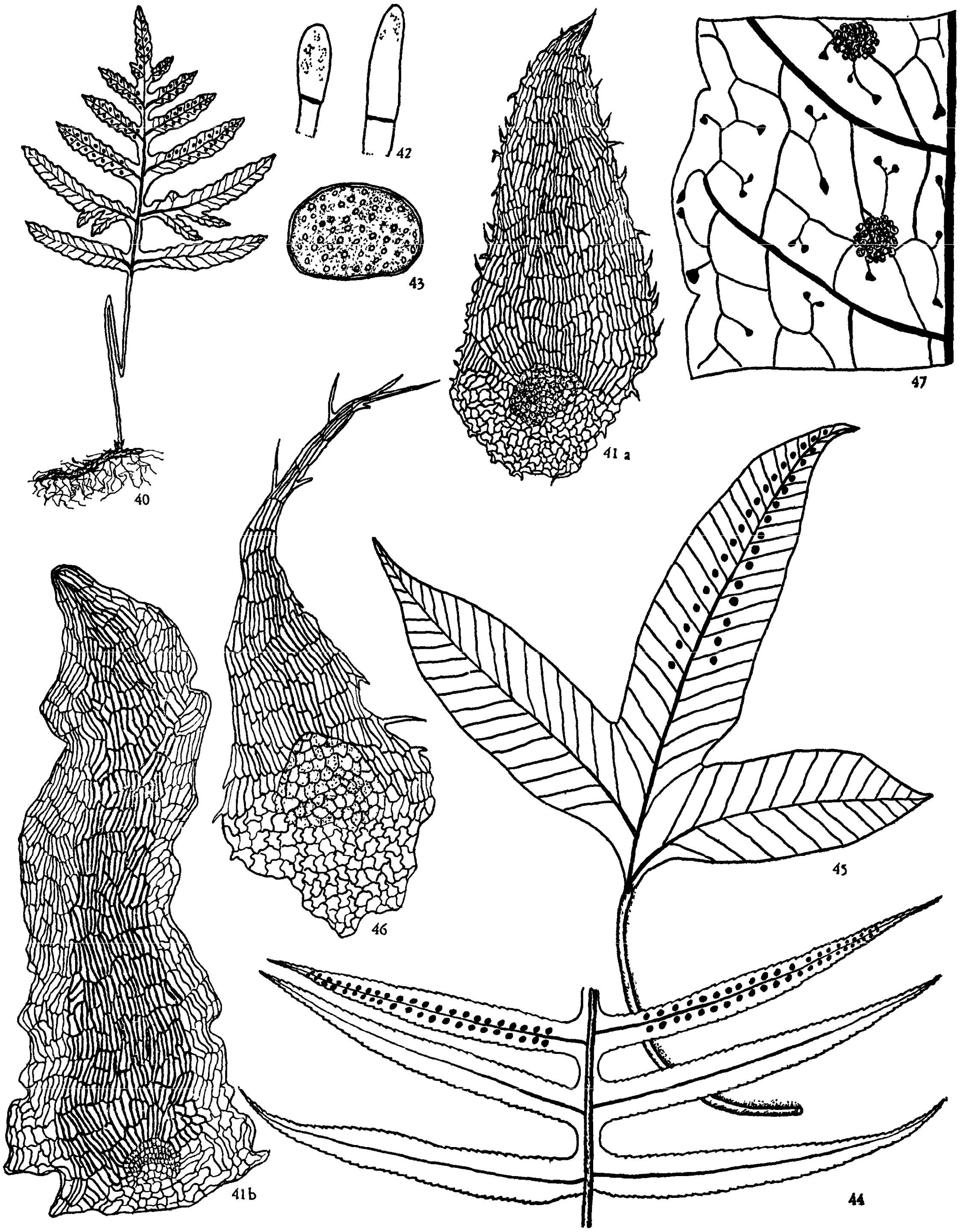
Young plants bear only trilobed fronds which are very much small-sized. These were called var. *thunbergii* by Clarke (1880). *Polypodium trifidum* Don, actually belongs to *P. oxyloba* (cf. *Sledge,* 1960) and not to this species as previously considered by Christensen (1906).

In the outline of the frond this species very much resembles *P. oxyloba* and *P. montana* but from both of these it can be distinguished primarily by the fact that the main lateral veins are very much raised on the undersurface and the texture is thick, rough and coriaceous. Also the margin of the lobe is cartilaginous and thick.

Specimens examined: EASTERN HIMALAYAS: DARJEELING: *Malhotra* Aug. 1954 (PAN 1117-18, 3058). SIKKIM: Chungthang (1,800 m), *Bir* 1038, July 1958 (PAN 3820-23). ASSAM: Shillong, Khasi Hills (US 9935); 1,500 m, *Mann* July 1888 (US 329710). SOUTH INDIA: KODAIKANAL: Moir Point (2,100 m), *Bir* June 1962 (PAN 4817).

Phymatodes oxyloba (Wall. ex Kunze) Presl, Tent, Pterid., 196. 1836; Alston & Bonner in Candollea 15: 206. 1956. Mehra & Bir in Res. Bull. Panjab Univ. (n.s.) 15: 171. 1964. *Polypodium oxylobum* Wall. ex Kunze in Linnaea 24: 255. 1851; C. Chr., Index Fil. Suppl. II. 55. 1917, cum. Syn. *Polypodium trifidum* D. Don, Prodr. Fl. Nepal. 3. 1825 (non *P. trifidum* Hoffm., 1790); Hook. & Bak., Syn. Fil. ed. ii. 363. 1874 (pro parte). *Pleopeltis hastata* sensu Bedd., Handb. Ferns Brit. India 362. 1883 (pro parte). *Polypodium hastatum* var. *oxyloba* Clarke in Trans. Linn. Soc. Lond. II. Bot. 1: 563. 1880 (pro parte). *Crypsinus oxylobus* (Wall. ex Kunze) Sledge in Bull. Brit. Mus. (nat. Hist.), 2 (5) 145. 1960.

Rhizome thick, stout, widely creeping, dotted with prominent frondiferous bases, densely paleaceous, 3-5 mm in diameter; scales ferruginous or brown, linear-lanceolate, peltate, non-clathrate attached towards or near the base, with the basal flaps overlapping, upto 6 mm long and 2 mm wide at the base, margin finely ciliate-lacerated due to the presence of hairy projections; stipes 8-25 cm long, thick, firm erect, yellowish-brown, glabrous, glossy; lamina 20-40 cm long and 13-25 cm wide, deeply pinnatifid within a short distance (½-1½ cm) of



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rachis, possesses a large linear-lanceolate terminal lobe and 1-8 pairs of similar lateral lobes; all pinna lobes of the same shape, lanceolate-acuminate with broad base, separated from each other by a scooped out rounded sinus of the same width as the lobe or narrower, basal pair broadly spreading and decurrent down below on the rachis, 10-15 cm long, 1½-3 cm (rarely upto 5 cm) wide, margin smooth and entire; texture subcoriaceous, both surfaces glabrous, colour bright-green to brown when dry; mid vein and main lateral veins prominent, transverse veinlets not so distinct and anastomosing to form small areolae with free included veinlets; sori one in between each main lateral vein and in one row on either side of the midrib, submedial, rounded, large, dark-brown, sunken; sporangial paraphyses simple, 2-3 celled small and hair-like; annulus cells 11-15; spores yellowish-brown, bilateral, reniform or ovoid, concavo- or plano-convex, exospore thick, echinated, exine granulated and occasionally spinescent (in some specimens the spores are of irregular sizes and shape), 48-61 × 32-42 μ (Figs. 9, 50-53).

It is met with as an epiphytic or on rocks throughout the Himalayas from Simla eastwards to Darjeeling and Sikkim State extending to Assam between 1,500-3,600 m altitude.

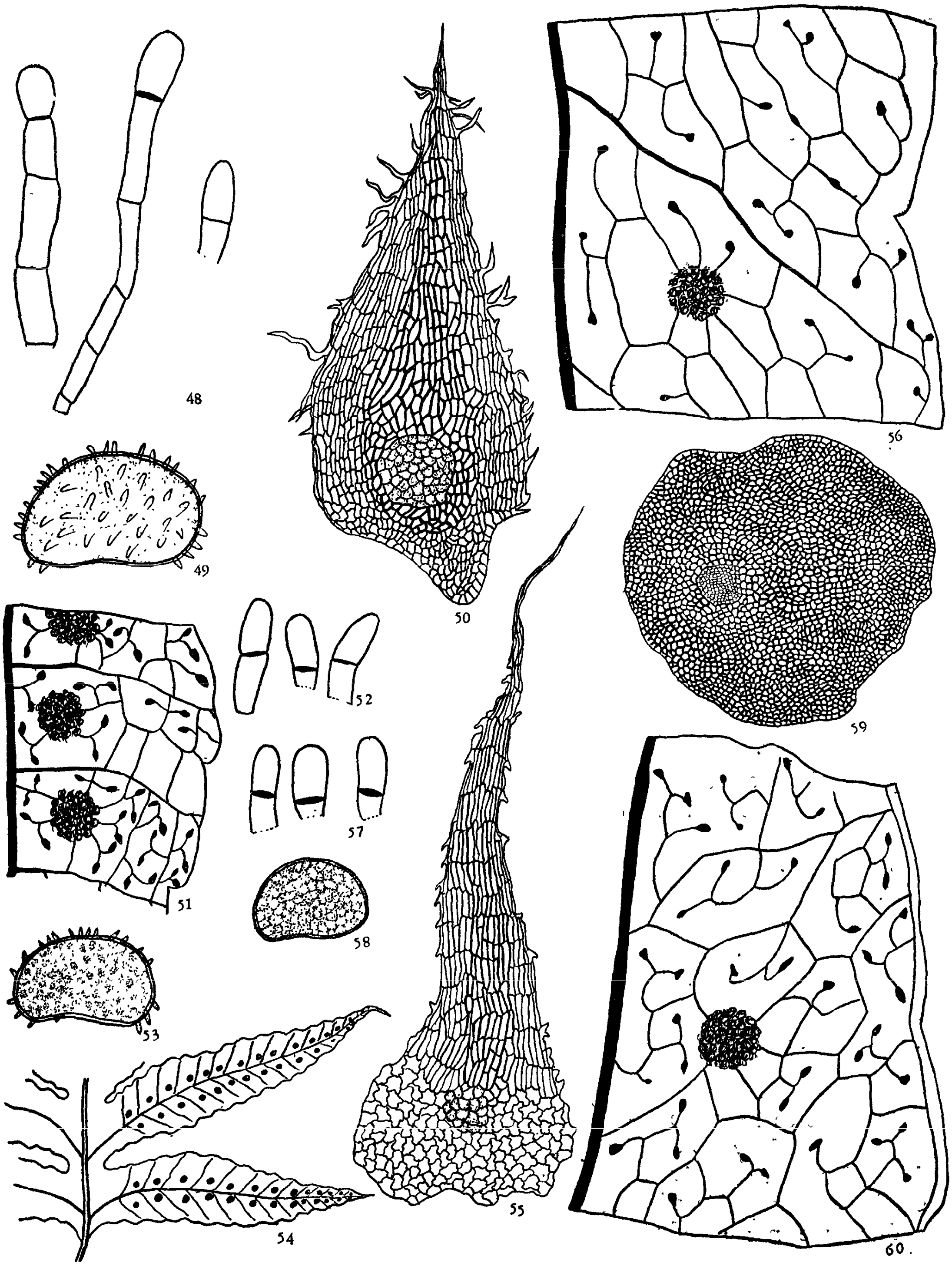
Distribution: Himalayas.

It is also reported from several places in South India (Palni, Nilgiris Hills etc.) but all the herbarium specimens available to the writers were found to be *P. montana*. It is just possible that the typical *P. oxyloba* is met with only in the Himalayas. Beddome's illustrations (1864 t. 175 and 1883 t. 205) pertain to *P. montana* and not to *P. oxyloba* or *P. hastata* as stated. The lamina in case of the present species often exceeds 50 cm in length and possesses upto 8 pairs of lobes which may be upto 5 cm in width and the margin is always entire. The rhizome scales are also long ciliated and particularly more so near the apex. Simple 3-lobed forms were named by Don as *Polypodium trifidum* or by Beddome as *Pleopeltis trifida* and were often considered conspecific with *P. hastata*, but actually these are not exactly the same as Thunberg's Japanese specimens of *Polypodium hastatum*. However, it may be pointed out that trilobed fronds are met with in all the three species, namely, *P. hastata*, *P. oxyloba* and *P. montana* but these can conveniently be separated in each case by the fact that in *P. montana* these have repand-crenate lobed margin, in *P. oxyloba* smooth margin and finally in *P. hastata* these have almost smooth cartilaginous margin but rough or extremely thick texture with all veins especially the main lateral veins very prominently raised on the undersurface, very much unlike that of *P. oxyloba* where the texture is almost subcoriaceous or herbaceous.

Specimens examined: Isotype: *Polypodium oxylobum* Wall. ex Kunze (Linnaea 24: 255. 1851) from Kumaon, *Wallich* 294 in 1827 (US 1277841). WESTERN HIMALAYAS: MUSSOORIE: Jabarkhet (1,500 m), *Bir* Sept. 1959 (PAN 2593-95); 1,800-1,950 m, *Mackinnon* in 1878-79 (US 1872556); 1,800-2,100 m, *Stewart* 14459, Aug. 1934 (US 1759649); Jabarkhet Tehri Road (2,100 m), *Stewart* 21054, Aug. 1944 (US 2017526). EASTERN HIMALAYAS: DARJEELING: Lebong Road (2,000-2,100 m), *Bir* June 1963 (PAN 4939, 5310); *Malhotra* Aug. 1954 (PAN 3057, 3059); Pankhawari Road, Kurseong (1,000 m), *Bir* 255, Aug. 1956 (PAN 5074). NEPAL: Samela (2,100 m), *Polunin, Sykes & Williams* 5649, Oct. 1952 (US 2360485).

Phymatodes montana (Sledge) comb. nov. *Crypsinus montanus* Sledge in Bull. Brit. Mus. (nat. Hist.) 2(5): 145. 1961. *Pleopeltis oxyloba* Bedd., Ferns South. India 59. t. 175. 1864 pro parte; (non D. Don). *Pleopeltis hastata* Bedd., Handb. Ferns Brit. India. 362. 1883 pro parte (non *Polypodium hastatum* Thunb).

Rhizome widely creeping, thick about 1-6 cm in diameter, frondiferous bases prominent, densely scaly throughout; scales linear, pale-brown, ferruginous, about 5 mm long and 1 mm wide, peltate, base broad and rounded, apex acuminate, margin minutely serrate-dentate, marginal teeth formed by excurrent marginal cells; stipes distant apart, born on frondiferous bases from 8 to 17 cm long, naked; lamina 10-25 cm long and about 8-16 cm wide, ovate-deltoid, deeply pinnatifid about 5 mm of the rachis; pinna lobes 2-6 pairs excluding the large elongated terminal one, separated from each other by generally a (wide space) more than the width of the lobes, the basal or the sub-basal one is the largest, 7 to 12 cm long, 1.5 to 2.5 cm wide, oblong-lanceolate with acuminate apex, base decurrent on the stipe, margin shallowly remotely dentate or deeply notched; texture firm, subcoriaceous, glabrous on both surfaces; main lateral veins prominent, veinlets distinct, anastomosing to form areolae with free included veinlets which end in promi-



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nent hydathodes; sori large, subimmersed, in one row on either side of the midrib, more near the midrib than the margin; sporangial paraphyses simple hair-like, usually two-celled; spores pale-yellow, bilateral, reniform plano- to concavo-convex, exine smooth (Figs. 54-58).

It is widely distributed in Anaimalai, Nilgiri, Palni and Shevaroy Hills in South India between 1,500-2,200 m.

Distribution: South India and Ceylon.

The sori are not totally superficial as mentioned by Sledge but these are partially sunken in cavities. Though, this species resembles very much Himalayan *P. oxyloba* in having almost similar shape and size of the frond and lower pair of pinnae decurrent at base on the stipe but it can conveniently be separated by (*i*) Rhizome scales have only minutely serrate margin as compared to *P. oxyloba* in which the scales have largely lacerated-ciliated margin. (*ii*) The margin of the pinna lobe is clearly dentate or notched as compared to smooth and entire margin in *P. oxyloba.* (*iii*) Pinna lobes are narrow in size, only about 1 to 2 cm as compared to usually 2.5 to 5 cm in *P. oxyloba.*

According to Sledge (1960), the specimens of this species from South India were previously referred to *P. oxyloba.*

Specimens examined: SOUTH INDIA: Only two specimens from Shembaganur, Kodaikanal, *Sauliere* Sept. 1913 (US 1506906-07), and one from Kodaikanal, Palni Hills (2,190 m), *Saldhana* Sept. 1959 (BLAT 4528) were available for study. The rest of the citation is taken from Sledge (1960). Anaimalai Hills 1,525 m, *Beddome* [original of Beddome, Ferns S. Ind. t. 175 (K)]; Nilgiri Hills, *Beddome* 99 (K); Sispara, Nilgiri District, 2,125 m, Nov. 1883, *Gamble* 13408 (K); Rallia, Nilgiri District 2,125 m, Oct. 1883. *Gamble* 13152 (K); Pykara, Nilgiri District, 1,825 m, June 1883, *Gamble* 12092 (K); same locality, riverside on trees, June 1908, *Bourne* 5122 (K). Nadiwattam, Nilgiri District, 1,825 m, Oct. 1886, *Gamble* 18285 (BM, K); same locality, May 1889, *Gamble* 20552 (K); Kotagiri, Nilgiri Hills, c. 1850, *Miss Cockburn* 70 (BM); Bear shola, Kodaikanal, Palni Hills, May 1898, *Bourne* 4959 (K); Pillar rocks stream, Kodaikanal, Palni Hills, June 1898, *Bourne* 4960 (K); Palni Hills, 1,700 m, *Sauliere* 154, 433, 439 (K); Shevaroy Hills, *Faucheux* (BM).

Phymatodes nigrescens (Bl.) J. Sm., Ferns Brit. & For. 94. 1866; Holtt., Fl. Malaya. 2: 193. 1954. *Polypodium nigrescens* Bl., Enum. Pl. Jav. 2: 126. 1828; Fl. Jav. Fil. 161. t. 70. 1847; C. Chr., Index. Fil. 547. 1906. *Pleopeltis nigrescens* (Bl.) Bedd., Handb. Ferns Brit. India. 367. 1883. *Microsorium alternifolium* Copel., Gen. Fil. 197. 1947, pro parte (non *Polypodium alternifolium* Willd.). *Microsorium nigrescens* (Bl.) Copel. in Occas. Papers Bishop Mus. 14: 74. 1938; Sledge in Bull. Brit. Mus. (nat. Hist.), 2(5): 144. 1960.

Rhizome widely creeping, thick 5-10 mm in diameter, with long tufts of roots on lower side, densely covered with scales near the apex but sparsely on the older portion; scales greyish-black, broadly ovate or circular, clathrate, 5 mm long and 8 mm wide, margin dentate because of the presence of glandular deciduous hairs; stipes 9-24 cm long, far apart, pale-yellow, thick, glabrous, elongated and stout; lamina 26-60.4 cm long and 13-30 cm wide, broadly ovate with base decurrent on the stipe, deeply pinnatifid; pinna lobes generally 3-4 pairs exclusive of the apical one which is of the same size and shape as the lateral ones, rarely only one pair or quite often upto 12 pairs in fully developed frond, 12-35 cm long and 3-4.7 cm wide, lanceolate, apex acuminate, glabrous, wing in between the lobes broad (more so on the lower base of the lobe) margin nearly entire, often sinuous or slightly undulate and very close to the veinlets forming second series of smaller areolae; texture subcoriaceous; venation distinct, main lateral veins traceable upto margin where these fork, veinlets forming two distinct series of primary areolae between the margin and midrib, the larger areolae oblique near the midrib, these primary areolae (large or small) are irregularly divided into secondary areolae, with free included simple or forked veinlets leading in hydathodes; sori on either side of the midrib in one row, more nearer the midrib than the margins, rounded or oblong, brown, deeply immersed and prominent on the upper surface as raised tubercles; paraphyses long thick-walled, simple, 4-6 celled and hair-like and along with these are more numerous club-shaped paraphyses with long stalks and heads composed of 5-6 cells arranged in two rows; annulus cells 12-15; spores hyaline or light-yellow, nonperisporiate, bilateral, reniform, ovoid plano-convex, exine smooth, 48-64 × 32-44μ (Figs. 10, 59-62).

It is met with on moist rocks or bases of trees in the plains of Assam (Eastern Himalayas) and on western ghats in South India (Nilgiris, Coimbatore, Kerala State etc.).

Distribution: North and South India, Ceylon, Malaya, Polynesia and Australia.

This species usually bears stipes and fronds much shorter and few pinna lobes as compared to

P. longissima. The lobes are long acuminated at apex and are broadly (especially on inferior base) decurrent on the stipe with edge very close to the outer series of smaller areolae. Copeland (1947) has united this fern with *Microsorium alternifolium* (Willd.) Copel. and was followed by Nayar (1961). But in the opinion of the writers *Polypodium alternifolium* Willd. is much a different fern than this species, because in the close up photograph of Willdenow's type specimen (present in U. S. Nat. Herb., also fig. 11) the main lateral veins are indistinct and are thus like *P. scolopendria.* In case of this fern the main lateral veins are prominent.

Specimens examined: EASTERN HIMALAYAS: ASSAM: Sylhet, Chatterchuroi Hills, *Mann* Sept. 1890 (US 329712). SOUTH INDIA: MADRAS: Sholaiyar, submergible area (1,030 m), *Sebastine* 17278, Aug. 1963 (MH 34002); KERALA: Calicut, Chedaleth (900 m), *Ellis* 19956, Sept. 1964 (MH 38420).

Phymatodes longissima (Bl.) J. Sm., Cat. Cult. Ferns. 10. 1857; Holtt., Fl. Malaya 2. 191. 1954. *Polypodium longissimum* Bl., Enum. Pl. Jav. 127. 1828 and Fl. Jav. Fil. 159. t. 68. 1829. *Polypodium rubidum* Kze. Bot. Zeit. 117. 1848. *Pleopeltis longissima* Moore, Index Fil. lxxviii. 1857; Bedd., Handb. Ferns Brit. India. 366. 1883. *Microsorium rubidum* (Kunze) Copel., Gen. Fil. 197. 1947; Nayar in Bull. nat. Bot. Gard. Lucknow No. 58 pp. 14-15. 1961.

Rhizome thick, hard, widely creeping, branched, upto 1 cm in diameter, almost naked throughout except for the apex where the scales are in tufts; scales broadly ovate, dull to dark-brown, margin almost smooth, bearing in young stage few deciduous glandular hairs, 3-6 mm long, 2-3 mm wide at base; stipes distantly placed (upto 8 cm apart) very much elongated (30-60 cm long), stout, glossy, more or less dull-brown, smooth, naked; frond about 110 cm or rarely more long, 25-50 cm wide, very deeply lobed, almost close to the midrib (wing imperceptible and 1-3 mm wide) narrowly elongate, oblong or lanceolate; pinna lobes 10-20 pairs, 1-1½ cm wide, linear-lanceolate with broad decurrent base and narrowed to a pointed tip, edges slightly reflexed and nearly straight; texture thin but firm, colour light-green or rather dull brownish, both sides glabrous; venation faintly conspicuous, the main lateral vein not prominent, veinlets forming two series of areolae between midrib and edge, larger ones near the midrib and smaller ones near the edge and these include simple or forked veinlets with slightly clavate apices; sori in a single row, very close and on each side of the midrib, deeply embedded and forming a prominent 1-2 mm raised tubercles on the upper surface, brown, oblong, 2-3 mm in diameter; sporangia protected when young by many filamentous long stalked paraphyses with multicellular heads composed of a series of ballon shaped cells present in 2-3 rows; annulus cells 13-20; spores light-yellow, plano-convex to concavo-convex or oblong, exine smooth, 35-64 × 32-49 μ (Figs. 63-67).

It is met with in Assam (Eastern Himalayas) and on Western ghats in South India at lower elevations, often cultivated. It grows on moist shaded rocks or bases of tree trunks.

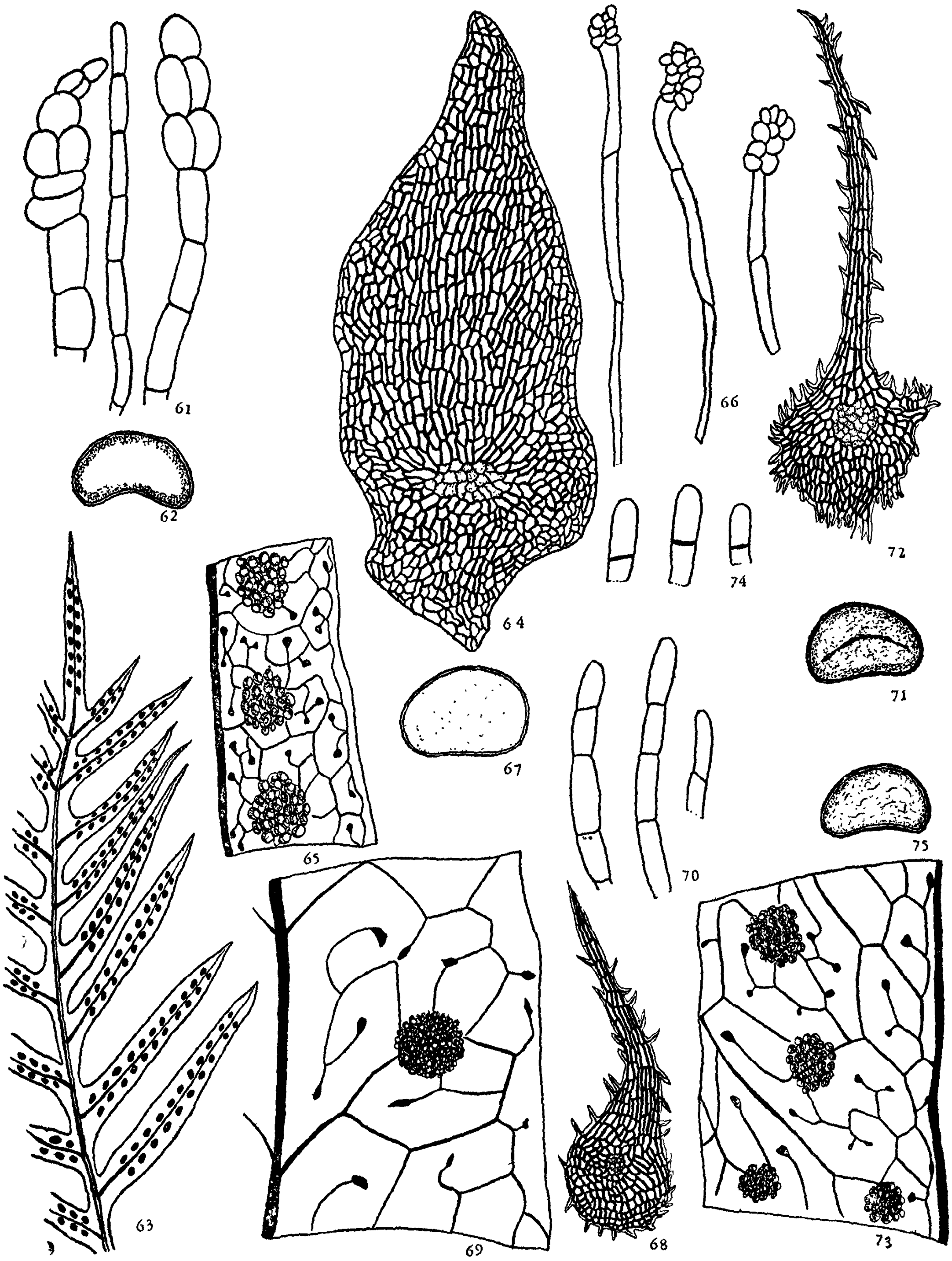
Distribution: Tropical Asia (North and South India, Polynesia, Ceylon, Malaya, Indochina etc.).

This species is very poorly represented in the Indian herbaria, evidently quite rare. It is quite closely allied to *P. nigrescens.* Both are very variable in size which depends upon the habitat in which they grow but can be recognised amongst rest of the members of the genus by deeply immersed sori, making prominent protuberances (1-2 mm raised) on the upper surface. In case of *P. nigrescens* the pinnae lobes are larger in size and are much broader with wavy edges, whereas in the present species the pinnae lobes are smaller in size and much narrower with edges prominently curved.

Specimens examined: EASTERN HIMALAYAS: ASSAM: Sibsagar (Bungpore) station, *Mann* Jan. 1890 (US 329711).

Phymatodes scolopendria (Burm. f.) Ching in Contr. Inst. Bot. nat. Acad. Peiping 2:63. 1933; Holtt., Fl. Malaya 2.191.1954. *Polypodium scolopendria* Burm. f., Fl. Ind. 232.1768. *Polypodium phymatodes* L., Mant. Pl. Alt. 306. 1771. *Polypodium alternifolium* Willd. in L., Spec. Plant. ed. 4, V. 168. 1810. *Pleopeltis phymatodes* (L.) Bedd., Ferns South. India 57. t. 173. 1864; Handb. Ferns Brit. India 366. 1883. *Microsorium scolopendria* (Burm. f.) Copel. in Univ. Calif. Publ. Bot. XVI: 112. 1929; Sledge in Bull. Brit. Mus. (nat. Hist), 2: 143. 1960.

Rhizome very wide creeping, 4-7 mm in diameter, fleshy green, sparsely scaly except for the young part; scales dark-brown, clathrate, peltate, lanceolate, acuminate with broad rounded base, margin dentate due to the presence of prominent projections,



Explanation to figures on page 217

length 3-4 mm, and upto 1½ mm wide; stipes smooth, firm, glossy, erect, yellowish-brown upto 35 cm long, frond upto 35 cm long and as much wide, oblong-lanceolate, deeply lobed to about 1-2 cm of the midrib with 2-5 (rarely more) pairs of lobes, light-green in colour; texture thinly leathery, coriaceous; pinna lobes of about the same width in the lower ⅘ portion and above acuminate (of ovate-lanceolate shape), apical lobe is of the same size as lateral ones, upto 22 cm long, 2½-4 cm wide, separated from each other by sinuses which are as much or slightly more (upto 1.5 times) wide as lobes, edges smooth, both surfaces glabrous, upper shinning; venation inconspicuous, anastomosing to form 2-3 primary areolae which include numerous smaller ones with 2-3 free included veinlets; sori in 2-3 irregular rows on either side of the midrib, scattered, large, rounded or elliptic 2-5 mm in diameter, brown in colour, shallowly sunk, the upper surface of the frond raised opposite each sorus; paraphyses simple, elongated, 3-5 celled, hair-like structure; annulus cells 13-16; spores light-yellow in colour, bilateral, reniform to concavo-convex, ovoid, non-perisporiate, exine smooth, granulated and thick, 29-58 × 23-38 μ (Figs. 11, 68-71).

It is met with in Nicobar Islands at low altitude. In South India the fern is reported from Malabar and Travancore, usually found in cultivation. It generally grows on trees or rocks in exposed situations.

Distribution: Tropical Africa, Ceylon, South India, South China, Malaya, Polynesia and Australia etc.

Specimens examined: NICOBAR ISLANDS: Kojoernga (6 m), *Thothathri* .9318, March 1959 (MH 18275). SOUTH INDIA: Specimen without any specific locality, *Meade* (US 9933).

Phymatodes banerjiana Pal & Pal in Amer. Fern Journ. 53: 103-104. 1963.

Rhizome thick. 5-9 mm in diameter, woody, sparsely scaly; scales blackish-brown, concolorous, adpressed linear-subulate, elongated with broad base and acuminate apex, clearly clathrate, with prominent marginal projections, upto 4 mm long and 0.8 mm wide; stipes 15-25 cm smooth, dull-brown, firm, erect, glossy, glabrous; fronds 20-35 cm long, 10-25 cm wide, ovate- or oblong-lanceolate, deeply lobed to within ½ cm of the rachis, glabrous on both sides, upper surface glossy; texture herbaceous, colour dull-green, terminal pinna is about the same size as lateral ones; lobes 5-11, rarely 17 pairs, narrowed at base, widest in the middle and accuminated at apex, 7-15 cm long, 1-2 cm wide, sinuses between lobes widened about two times or more than the width of the lobes; venation inconspicuous, no distinct main lateral veins, primary areolae 1-2 between midrib and margin, within these are secondary areolae with free included veinlets; sori in two irregular rows on either side of the midrib, small-sized, rounded or elongated, deeply immersed; paraphyses simple, short and two-celled; annulus cells 11-15; spores hyaline or pale yellow, reniform, elliptic in polar view, 32-57 × 22-35 μ (Figs. 12, 72-75).

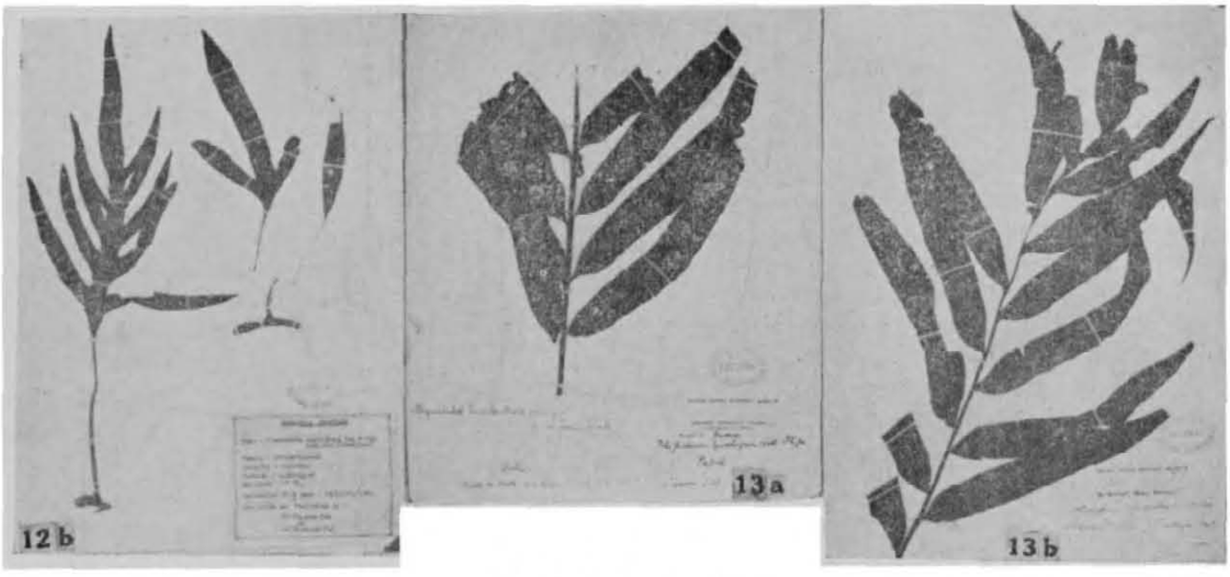


Plate III (Figs. 12b-13b)

12b. *Phymatodes banerjiana* Pal & Pal (US 2358074). 13a, b. *Phymatodes cuspidata* (Don) J. Smith (=*Polypodium leiorhizum* Wall., US 1277847, 1277930)—all Isotypes.

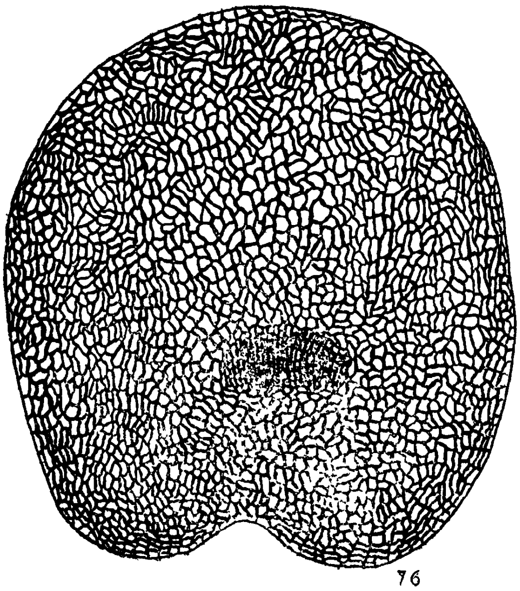
This new species of *Phymatodes* was described by Pal & Pal (1963) from material under cultivation in Bose Research Institute, Calcutta; Science College, Calcutta University and the Indian Botanic Garden, Howrah.

Distribution: India.

This species as pointed out by Pal & Pal (1963) is very closely allied to *P. scolopendria* but can be distinguished by; (*i*) thicker rhizome, (5-9 mm diameter), (*ii*) short stipes (15-25 cm) as compared to at least 35 cm in *P. scolopendria*, (*iii*) herbaceous texture of the blade, (*iv*) the sinus in between the lobes upto 2.5 times broader than the width of the lobes but in *P. scolopendria* it is only upto 1.5 times broader, (*v*) the lateral lobes of lamina always narrower than in case of other species, (*vi*) the rhizome scales always smaller in size than those of *P. scolopendria* and finally, (*vii*) by the differentiation of the lateral lobes which are broadest in the middle in the present species, while in *P. scolopendria* these are nearly as much broad at the middle as at the base.

Specimens examined: Isotypes: CALCUTTA: (15 m), *S. Pal & N. Pal* 14, July 1960-61 (US 2358071-2358072).

Phymatodes cuspidata (Don) J. Smith, Cal. Cult. Ferns, 10, 1857; Alston & Bonner in Candollea. 15: 206. 1956. *Polypodium cuspidatum* Don, Prodr. Fl. Nepal. 2. 1825. *Polypodium lucidum* Roxb. in Cal. Journ. nat. Hist., 4: 486. 1844. *Pleopeltis leiorhiza* Moore, Index Fil, 346. 1862; Bedd., Ferns South. India t. 174. 1864, and Handb. Ferns Brit. India 373. 1883. *Polypodium leiorhizum* Wall., List. n. 303. 1828 (nomen nudum); Clarke in Trans. Linn. Soc. Lond. II. Bot. 1: 567. 1880. *Phymatodes lucida* (Roxb.) Ching in Contr. Inst. Bot. nat. Acad. Peiping 2: 61, 1933; Mehra & Bir in Res. Bull. Panjab Univ. (n.s.) 15. 172. 1964. *Microsorium lucidum* (Roxb.) Copel., Gen. Fil. 196. 1947; Nayar in Bull. nat. Bot. Gard. Lucknow, No. 58, pp. 22-24.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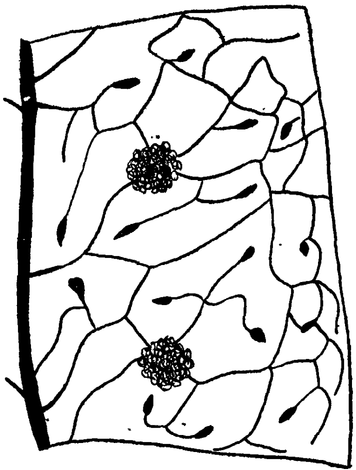
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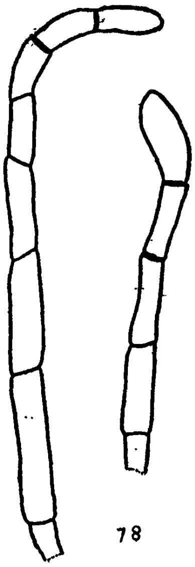
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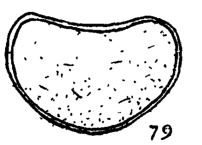
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Explanation to figures on page 217

Rhizome very thick, fleshy, widely creeping, about 1 cm or more in diameter, light-green to pale-brown in colour, sparsely scaly, even near the growing point the scales are few; scales large, 5-8 mm long and 2-4 mm wide at base, adpressed, ovate or somewhat roundish and circular, prominently clathrate in the middle, slaty-brown, peltate, the basal flaps overlapping, in the mature one the margin is smooth, but in the young condition few marginal glandular hairs are present; stipes 1-3 cm or more apart in two alternating rows on upper surface, thick, erect, elongated 19-60 cm long, 5 mm or more in diameter, yellowish-brown, glabrous, phyllopodia thick and prominent, ½-1 cm long; lamina 30-80 cm long and 25-50 cm wide, erect, ovate, distinctly pinnate (rarely deeply pinnatisect with the bases of pinna lobes decurrent on the stipe and the wings on either side of lobe widen towards the apex of the frond); pinna 6-15 pairs, narrow, lanceolate-linear, lower one distinctly stalked (stalk ¼-1 cm) upper ones sessile with decurrent base, all alternate or subopposite, distantly placed, apex long-acuminate, middle ones the largest, 15-30 cm long, 2-3 cm wide, margin entire and smooth, slightly chartaceous, both surfaces glabrous; texture thick, coriaceous, colour light or pale-green on drying; rachis erect naked and dull brown, midrib of pinnae prominent on both surfaces; venation inconspicuous, main lateral veins not prominent, veinlets anastomosing to form larger areolae near the midrib and smaller towards the margin, all areolae with many free branched included veinlets ending in hydathodes; sori near the midrib, than the margin, in a single row on each side of the midrib, large (3-4 mm), rounded, usually sunken and prominent on the upper surface, yellowish-brown; sporangial paraphyses long and consist of 5-10 cells, hair-like, the apical cell somewhat swollen; annulus 15-20 cells; spores yellowish-brown, large-sized, exine, thin, smooth or seldom with fewer granulations, 42-61 × 38-54 μ (Figs. 13, 76-79).

It is quite frequently met with in the Eastern Himalayas (Darjeeling, Sikkim State and Assam) and Western Ghats, upto 1,700 m altitude. At lower elevations this species is more common and grows gregariously in moist shady places either as an epiphyte on lower portions of tree trunks or on moist rocks. This is the only distinctly pinnate species of the genus in India.

Distribution: North and South India, S. W. China and Tonkin.

Polypodium cuspidatum Don is not antedated by *P. cuspidatum* Presl, as was assumed by Ching (1933) while adopting *Polypodium lucidum* Roxburgh as the valid name for this fern (cf. *Alston & Bonner* 1956).

Specimens examined: Isotypes: *Polypodium leiorhizum* Wall. ex. Mett. (Fil. Lips. 37. t. 25. f. 7. 1856) from Nepal *Wallich* 303 in 1820 (US 1277847, 1277930). EASTERN HIMALAYAS: DARJEELING: Sidrapong (1,200 m), *Bir* 152, Aug. 1956 (PAN 476, 1119-21, 1123), *Malhotra* Aug. 1953 (PAN 1122, 1124); Lebong (1,650 m), *Malhotra* Aug. 1954 (PAN 1295); Manjitar-Tista Road *Malhotra* 837, Aug. 1957 (PAN 3587-88); 400 m, Sept. 1910 (US 1431852). NEPAL: (US 594601); ASSAM: Shillong, Khasi Hills (1,200 m), *Mann* Oct. 1888 (US 329718) and some specimens without specific locality; *Griffith* 2723 (US 816846); *Biswas* 4712, Oct. 1940 (US 1758611).

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*Complete references to the original publication of the generic and specific name can be found in Christensen's *Index Filicum* (1905-1906) and Supplements I-III (1906-1933) and Pichi Sermolli's Index *Filicum Supplementum Quartum* (1934-1960).

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EXPLANATION TO FIGURES 14-79

Figs. 14-16 : *Phymatodes rhyncophylla* (Hook.) Ching
14. Rhizome scale. 15. Sporangial paraphyses. 16. Spore.

Figs. 17-20 : *Phymatodes griffithiana* (Hook.) Ching
17. Rhizome scales. 18. Venation. 19. Sporangial paraphyses. 20. Spore.

Figs. 21-25 : *Phymatodes malacodon* (Hook.) Ching
21. Habit sketch. 22. Rhizome scale. 23. Venation. 24. Sporangial paraphyses. 25. Spore.

Figs. 26-29 : *Phymatodes erythrocarpa* (Mett. ex. Kuhn) Ching
26. Habit sketch. 27. Rhizome scale. 28. Sporangial paraphyses. 29. Spore.

Figs. 30-34 : *Phymatodes stewartii* (Bedd.) Ching
30. Habit sketch. 31. Rhizome scale. 32. Venation. 33. Sporangial paraphyses. 34. Spore.

Figs. 35-39 : *Phymatodes stracheyi* Ching
35. Habit sketch. 36. Rhizome scale. 37. Venation. 38. Sporangial paraphyses. 39. Spore.

Fig. 40 : Habit sketch of *Phymatodes crenato-pinnata* (Clarke) Ching (from Clarke's original illustration).

Figs. 41-43 : *Phymatodes ebenipes* (Hook.) Ching
41a. Rhizome scale. 41b. Frond scale. 42. Paraphyses. 43. Spore.

Fig. 44 : A portion of the frond of *Phymatodes ebenipes* var. *oakesii* (Clarke) Bir & Devi.

Figs. 45-49 : *Phymatodes hastata* (Thunb.) Ching
45. Habit sketch. 46. Rhizome scale. 47. Venation. 48. Sporangial paraphyses. 49. Spore.

Figs. 50-53 : *Phymatodes oxyloba* (Wall. ex Kunze) Presl
50. Rhizome scale. 51. Venation. 52. Sporangial paraphyses. 53. Spore.

Figs. 54-58 : *Phymatodes montana* (Sledge) Bir & Devi
54. A portion of the frond. 55. Rhizome scale. 56. Venation. 57. Sporangial paraphyses. 58. Spore.

Figs. 59-62 : *Phymatodes nigrescens* (Bl.) J. Smith
59. Rhizome scale. 60. Venation. 61. Sporangial paraphyses. 62. Spore.

Figs. 63-67 : *Phymatodes longissima* (Bl.) J. Smith
63. A portion of the frond. 64. Rhizome scale. 65. Venation. 66. Sporangial paraphyses. 67. Spore.

Figs. 68-71 : *Phymatodes scolopendria* (Burm. f.) Ching
68. Rhizome scale. 69. Venation. 70. Sporangial paraphyses. 71. Spore.

Figs. 72-75 : *Phymatodes banerjiana* Pal & Pal
72. Rhizome scale. 73. Venation. 74. Sporangial paraphyses. 75. Spore.

Figs. 76-79 : *Phymatodes cuspidata* (Don) J. Smith
76. Rhizome scale. 77. Venation. 78. Sporangial paraphyses. 79. Spore.

MAGNIFICATIONS

Figs. 21, 26, 30, 35, 40, 44, 45, 54, 63 × Half natural size. Figs. 14, 17, 22, 27, 31, 36, 41a-b, 46, 50, 55, 59, 64, 68, 72, 76 × 30. Figs. 18, 23, 32, 37, 47, 51, 56, 60, 65, 69, 73, 77 × 6. Figs. 15, 19, 24, 28, 33, 38, 42, 48, 52, 57, 61, 66, 70, 74, 78 × 200. Figs. 16, 20, 25, 29, 34, 39, 43, 49, 53, 58, 62, 67, 71, 75, 79 × 380.